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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

# INVESTIGATION OF AN 8-INCH PROPELLER METER

Report No. Hyd-558

Hydraulics Branch
DIVISION OF RESEARCH

OFFICE OF CHIEF ENGINEER
DENVER, COLORADO

August 29, 1966

CONTENTS

## ABSTRACT

An 8-in. saddle-type propeller meter was calibrated in the laboratory for normal installation with 30 diameters of straight pipe upstream of the meter and for a severe test of accuracy with the meter installed 6 diameters downstream of a 90 deg mitered elbow. Discharges indicated by the propeller meter, obtained by timing the totalizer register in the meter head, were compared to values obtained simultaneously using the Venturi meters installed in the hydraulics laboratory for use as measuring devices. The Venturi meters, volumetrically calibrated, are accurate to within ±0.5% of the actual flow. The meter was tested in 2 different sizes of pipe, and the effect of flow straighteners on the meter accuracy was investigated. For the normal installation with flow straighteners, the meter accuracy was ±2% for discharges between 0.55 to 3.33 cfs; but the accuracy decreased in the lower range of 0.22 to 0.55 cfs. For the meter downstream of the elbow, the accuracy was ±2% for discharges from 0.65 to 3.33 cfs. In both installations, the meter read as much as 13% low at the minimum-rated discharge of 0.22 cfs. Flow straighteners increased the meter accuracy by as much as 1.5% in both installations. Tests of the meter in 2 sizes of pipe showed best accuracy when the inside diameter of the pipe was 8.00 in.

DESCRIPTORS-- *meters/ current meters/ *flow meters/ velocity meters/ Venturi meters/ *water meters/ closed conduits/ hydraulics/ pipelines/ water pipes/ *water measurement/ *laboratory tests/ fluid flow/ research and development/ irrigation/ discharges
IDENTIFIERS-- *flow straighteners/ *propeller meters
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Special Investigations Section
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# INVESTIGATION OF AN 8-INCH PROPELLER METER

## SUMMARY

The discharge characteristics of a new 8-inch saddle-type propeller meter, Figure 1, were investigated in the hydraulics laboratory as part of the Bureau of Reclamation's water measurement program for evaluating and developing water-measuring methods and devices.

Discharge measurement accuracy and operating characteristics were determined for the meter in two pipelines of different inside diameters. In one series of measurements, there were 30 diameters of straight pipe upstream of the meter in both lines. In a second test series, the discharge characteristics were determined for the meter installed 6 pipe diameters downstream of a 90° mitered elbow. The change in the accuracy of the meter was determined with and without the flow straighteners supplied with the meter in both test series.

The discharge through the propeller meter was measured by volumetrically calibrated Venturi meters. The meters installed in the Hydraulic Laboratory for use as measuring devices, are accurate to within plus or minus 0.5 percent. A discharge ratio, indicated propeller meter discharge divided by the measured discharge through the pipeline, was used as a measure of the accuracy of the meter for both installations. Calibration curves were drawn as best-fit lines through points plotted using the discharge ratio as the ordinate and the Venturi meter (actual) discharge as the abscissa, Figure 4, 5, and 6.

A meter accuracy within plus or minus 2 percent of the actual flow was obtained for discharges between 0.55 and 3.33 cfs (cubic feet per second) (245 to 1,500 gallons per minute). The meter was installed with flow straighteners in a 7.97-inch-diameter pipe and had 30 diameters of straight pipe upstream of the meter, Figure 4, Curve 2. The meter accuracy decreased rapidly for discharges less than 0.55 cfs. At the manufacturer's minimum rated discharge of 0.22 cfs, the accuracy of the meter used in this study could not be accurately measured. A 90° elbow installed about 6 diameters upstream from the propeller reduced

the meter registration by 1.7 percent in the 7.97-inch pipe, Figures 3 and 6. Flow straighteners upstream of the propeller increased the accuracy by about 1.5 percent in both meter installations. Installation of the meter in a pipe of less than 8.0 inches inside diameter causes the meter to overregister. For a slightly undersized pipe, 7.78 inches inside diameter, the meter registers about 7 percent too high (Curve 1, Figure 4). A pipe diameter of 7.97 inches caused about 1.2 percent overregistration (Figure 5, Curve 1).

## INTRODUCTION

The need for accurate and reliable water-measuring devices is becoming more evident as the use of irrigation water increases. As more and more land is placed under irrigation, the demand for water increases, necessitating a complete and accurate accounting of the flow from the main diversion structure to the farm turnout. The Bureau of Reclamation conducts a water measurement program for the purpose of evaluating new and existing flow-measuring devices to find better methods and improve the accuracy of water measurement.

The calibration of an 8-inch saddle-type propeller meter was performed in the Hydraulic Branch of the Bureau of Reclamation as part of the water measurement program.

## CALIBRATION FACILITIES

### Meter

The meter used for calibration studies was an 8-inch saddle-type propeller meter, of a type used in many irrigation districts and readily available for purchase (Figure 1A). The 7-inch-diameter plastic propeller and shaft housing was inserted into the pipe through a 5-inch-square hole cut into the crown of the pipe. The meter cover plate was sealed to the pipe against a rubber gasket using the three U-bolts which are a part of the meter assembly.

All of the metal parts of the meter except the packing unit on the propeller shaft and the meter head were coated by the manufacturer with a tough pliable plastic. The meter head contained a flow totalizing register that could be read to the nearest 0.0001 acre-foot (43.56 cubic feet). An instantaneous flow rate needle and dial graduated in increments of 100 gallons per minute was included in the register, Figure 1B. The rated range of the meter according to the manufacturer's catalog is 100 to 1,500 gallons per minute (0.22 to 3.3 cfs).

## Meter Test Facility

The propeller meter was installed in a 35-foot-long straight pipeline. A 90° mitered elbow was connected at the inlet to the pipeline. An 8-inch gate valve at the downstream end was used to control the discharge, Figure 2A. Couplings for the test pipe were of a sleeve type to facilitate assembly and disassembly of the pipe and test section. The propeller meter was installed in a short test section, Figure 2B, and this section was inserted in the pipeline at the desired location. Three 10-inch-long enameled straightener vanes 2 inches wide by 1/8-inch thick supplied with the meter could be installed just upstream of the meter propeller. Figure 3 shows the meter installed just downstream from the 90° mitered elbow.

## CALIBRATION PROCEDURE

Test discharges through the propeller meter were measured with the 4-, 6-, or 8-inch Venturi meters and controlled by the gate valve downstream from the propeller meter. The downstream valve was used to control the discharge, causing the test section to flow full, and preventing free-flow conditions at the propeller.

The total indicated volume of water passing the meter during a measured time interval was the difference in totalizer readings at the start and at the end of the interval. The time, measured by a stopwatch, for each test ranged from about 6 to 17 minutes for indicated flow volumes from 0.01 to 0.16 acre-foot (436 to 6,970 cubic feet). The discharge indicated by the propeller meter was determined by dividing the total indicated volume in acre-feet by the time interval, and converting to cubic feet per second. The flow rate indicator was read for each run and the reading compared with the flow rate calculated from the totalizer reading. The discharge measurement accuracy of the meter was determined by comparing the propeller meter indicated flow to the flow measured by permanently installed, volumetrically calibrated, Venturi meters.

## TEST SERIES

Six series of tests, i.e., six calibration curves, were made to study the discharge characteristics of the propeller meter for various flow positions and arrangements of the pipeline.

For Series 1, the meter was installed in a 3.5-foot-long test section of pipe (diameter 7.78 inches). The test section was inserted in the pipe with 36 diameters of straight pipe (diameter 7.78 inches) upstream of the test section. The flow straighteners were in place for this series. Twenty tests were made in this series for discharges between 0.47 to 3.55 cfs, Curve 1, Figure 4.

A 5-foot section of 7.97-inch-diameter pipe was used as the test section for Series 2 with 30 diameters of straight pipe (diameter 7.78 inches) upstream of the test section. Flow straighteners were in place for the series. Eighteen tests were made in Series 2 for discharges ranging from 0.32 to 3.35 cfs, Curve 2, Figure 4.

Series 3 was similar to Series 2 except the 30 diameters of straight pipe upstream of the test section had a diameter of 7.97 inches or the same diameter as the test section. Twenty tests, 0.40 to 3.27 cfs, with flow straighteners installed were performed, Curve 1, Figure 5.

In Series 4, the 5-foot-long test section of 7.97-inch pipe and 30 diameters of the same diameter pipe upstream of the test section were installed, but the flow straighteners were not in place. The calibration curve for Series 4 is Curve 2, Figure 5.

For Series 5 and 6, the 5-foot test section was installed downstream from a 90° mitered elbow of the same diameter as the test section (7.97 inches). The test section was installed 16 inches downstream of the elbow thereby placing the propeller about 6 diameters downstream of the elbow, Figure 3B. The flow straighteners were in place for Test Series 6, Curve 1, Figure 6, but were not installed for Series 5, Curve 2.

## DISCUSSION OF RESULTS

Results from Test Series 1, for which the pipe diameter was 7.78 inches, show a registration of about 107 percent for discharges larger than 1.0 cfs, Curve 1, Figure 4. Available literature from the manufacturer on installation of this meter did not indicate that an 8-inch-inside-diameter pipe is required or specify the allowable thickness of wall pipe. If an 8-inch-inside-diameter pipe is the design diameter, than the 7.78-inch-diameter pipe has a flow area 5.33 percent less than the design area. This area correction would help to offset the overregistration characteristics of the meter.

To investigate the effect of pipe diameter on the registration of the meter, Series 2, was performed using a test section diameter equal to 7.97 inches. The calibration curve for Series 2 shows a registration of about 101.2 percent for discharges above 1.0 cfs. The 7.97-inch pipe has a flow area 0.80 percent less than an 8-inch-inside-diameter pipe.

A third pipe with a diameter different from the two pipes tested was not available to determine whether the percent of overregistration for discharges over 1.0 cfs and pipe area reduction for the two pipes tested. Figure 7 indicates that for zero overregistration, the inside diameter of the pipe should be about 8.01 inches.

Test Series 3 and 4 determined (1) the measurement accuracy of the meter for 30 diameters of 7.97-inch-inside-diameter straight pipe upstream and (2) the effect of flow straighteners on the registration of the meter, Curves 1 and 2, Figure 5. Series 3, with flow straighteners, shows a registration of from 101 to 101.7 percent for discharges exceeding 1.0 cfs. Without flow straighteners, the meter registered about 102.5 percent of the actual discharge. Information available from the manufacturer did not indicate the accuracy specifications for this meter, but the general specification for propeller meters of this type is plus or minus 2 percent over the rated range of discharges. Discharge ratios between 98 and 102 would fall within the plus or minus 2 percent accuracy range. For this meter with flow straighteners installed in a pipe of diameter 7.97 inches, the plus or minus 2 percent accuracy is achieved for discharges from 0.55 to 3.5 cfs, Figure 5. For discharges less than 0.55 cfs, the discharge ratio decreases rapidly and at the manufacturer's recommended minimum flow (0.22 cfs) the discharge ratio could not be accurately measured. The propeller of this meter did not rotate when the discharge was 0.18 or 0.04 cfs less than the manufacturer's minimum discharge.

In Series 5 and 6, the meter was installed downstream from a 90° elbow to study the effect of the elbow on the meter registration with and without flow straighteners. The calibration curves resulting from Series 5 and 6, Figure 6, show that the registrations are lower for the meter installed downstream of the elbow than for the meter with 30 diameters of straight pipe upstream. With flow straighteners installed, the registration is about 99.5 to 100 for discharges greater than 0.8 cfs with the sharp decrease in registration for discharges below 0.8 cfs.

For the meter downstream of the elbow without flow straighteners, the registration is between 0 and 1.5 percent lower than with flow straighteners.

## CONCLUSIONS

The results and conclusions presented in this report were obtained from a series of tests performed on one new propeller meter and are indicative of the performance of this meter. Extrapolation of these results to other propeller meters of the same type may not be valid. No attempt was made to evaluate the meter reliability or performance on a long-term basis. To fully evaluate the meter, additional tests after 2 or 3 years of field operation would be required.

1. The 8-inch saddle-type propeller meter investigated in this study and installed in a 7.97-inch-inside-diameter pipe, with flow straighteners and 30 diameters of straight pipe upstream of the meter,

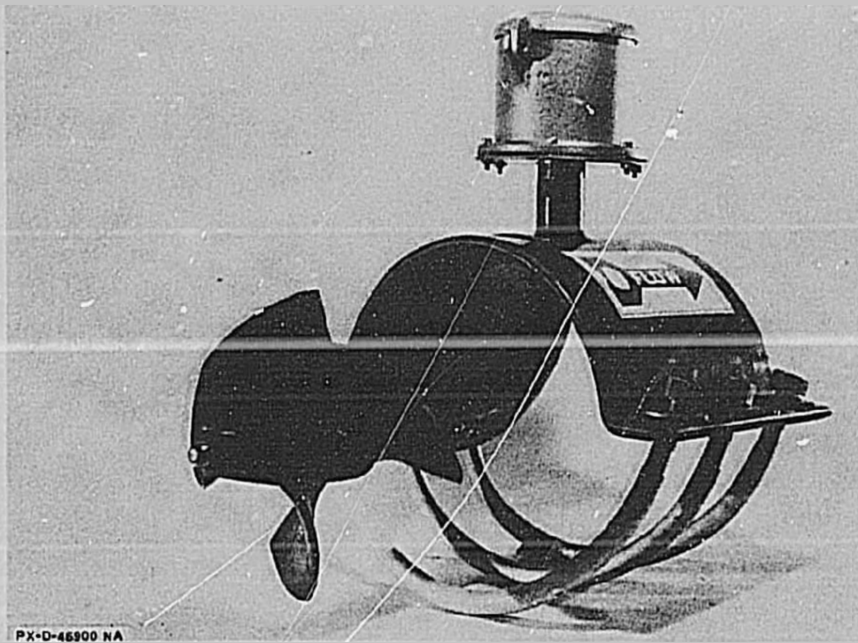
indicated discharges with an accuracy of plus or minus 2 percent between 0.55 and 3.33 cfs (245 to 1,500 gallons per minute).

2. For discharges below 0.55 cfs, the accuracy decreased rapidly and at the manufacturer's minimum recommended discharge, 0.22 cfs, the meter registration could not be accurately measured.

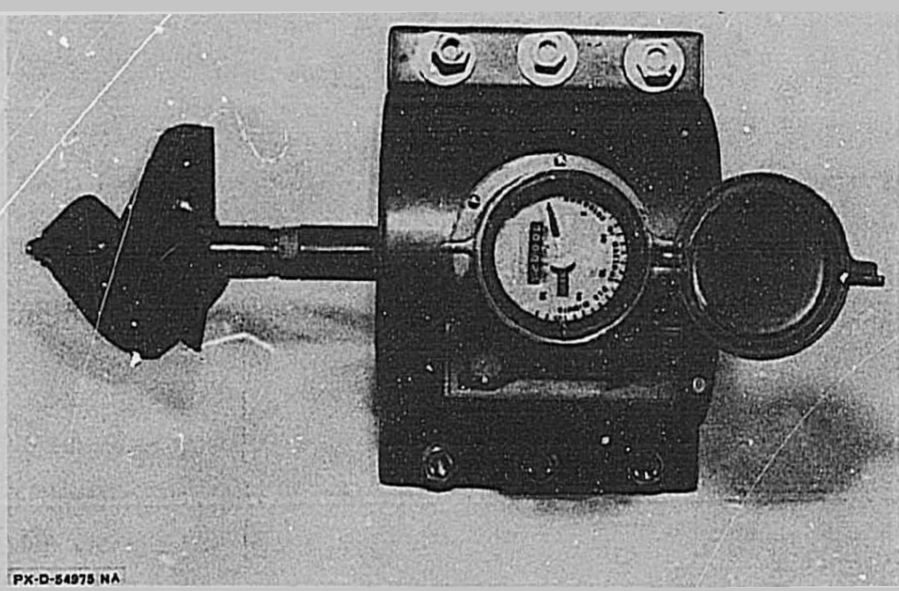
3. Flow straighteners increased the registration of the meter by as much as 1.5 percent, both for the meter installed with 30 diameters of straight pipe upstream and for the meter installed downstream of a a 90° elbow.

4. The meter registered about 1.7 percent less discharge when installed downstream of a 90° elbow than when installed with 30 diameters of straight pipe upstream of the meter.

5. The meter gave best accuracy when installed with flow straighteners in a pipe of 7.97-inch inside diameter. Smaller diameters caused the meter to overregister.




A. Eight-inch propeller meter used for laboratory calibration.




B. Propeller meter showing totalizer register and flow rate indicator.

PROPELLER METER STUDY
Eight-inch Saddle-type Propeller Meter

Figure 2
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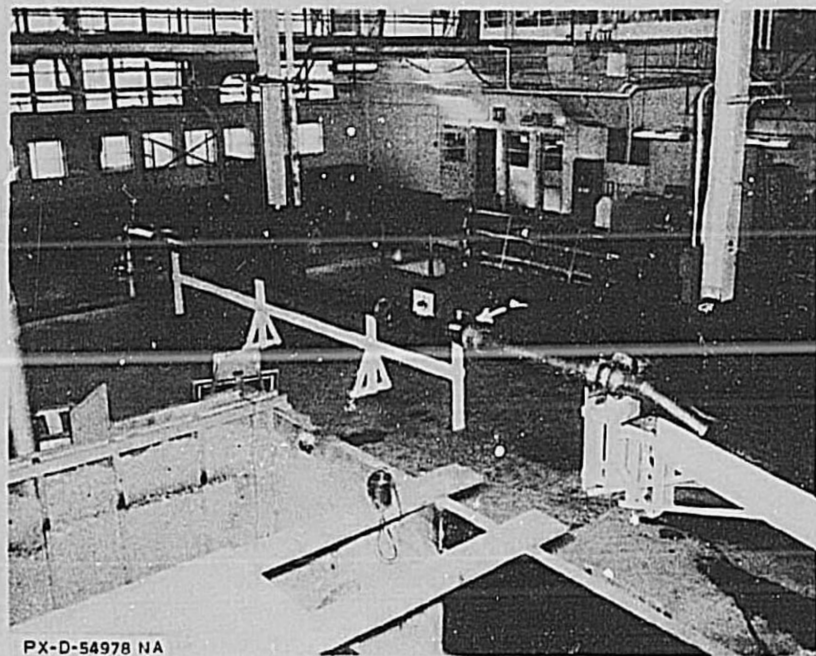
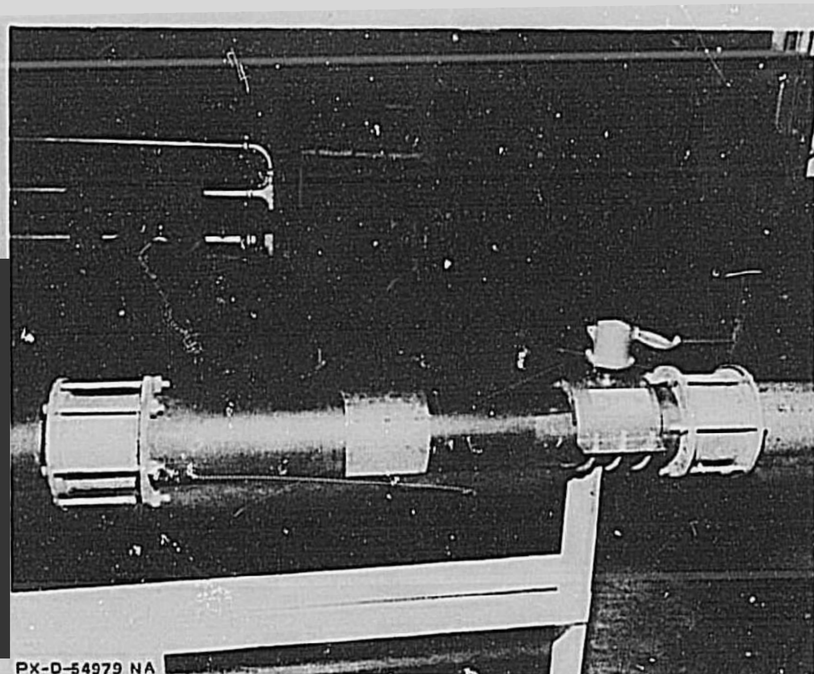
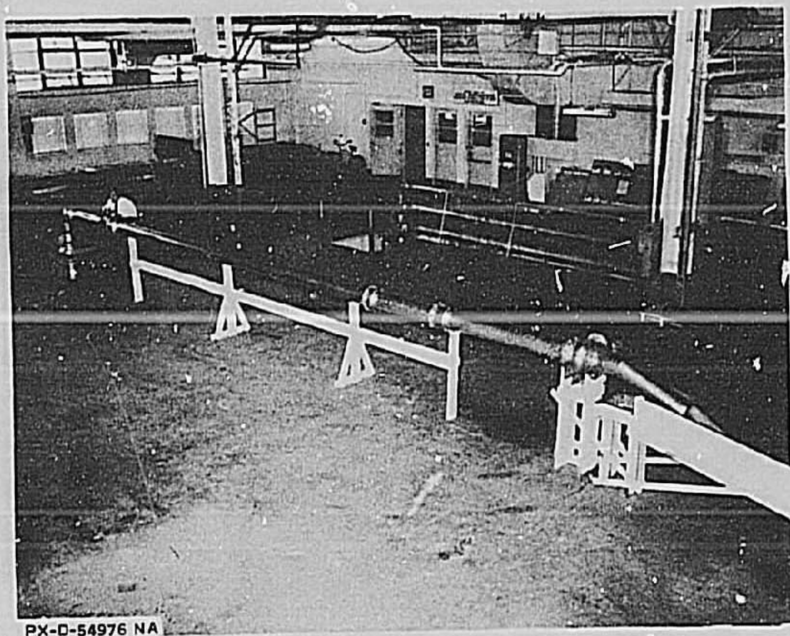



A. Laboratory facility for propeller meter calibration.

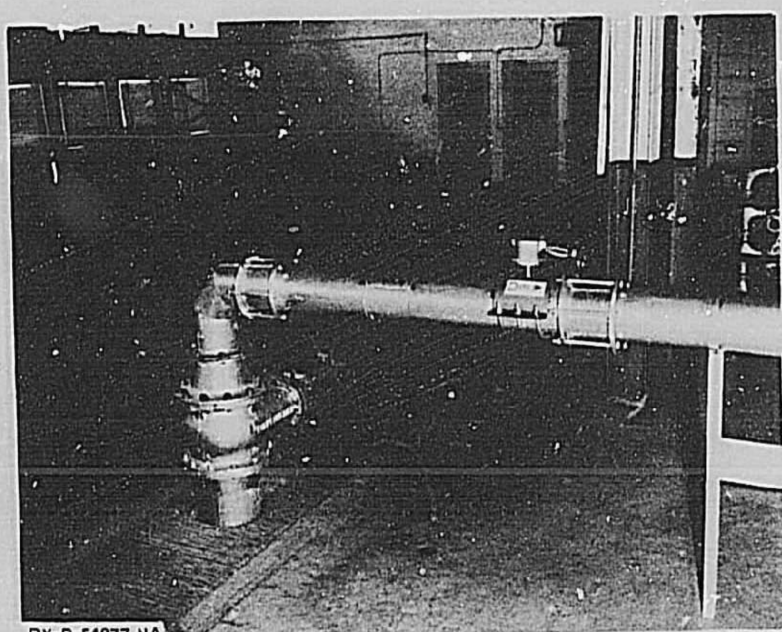



B. Eight-inch pipe test section with meter installed.

PROPELLER METER STUDY
Laboratory Test Facility and Meter Installation




A. Laboratory facility with meter installed downstream of 90° elbow.




B. Meter installed downstream of 90° elbow.

PROPELLER METER STUDY
Meter Installation Downstream of 90° Elbow

FIGURE 4
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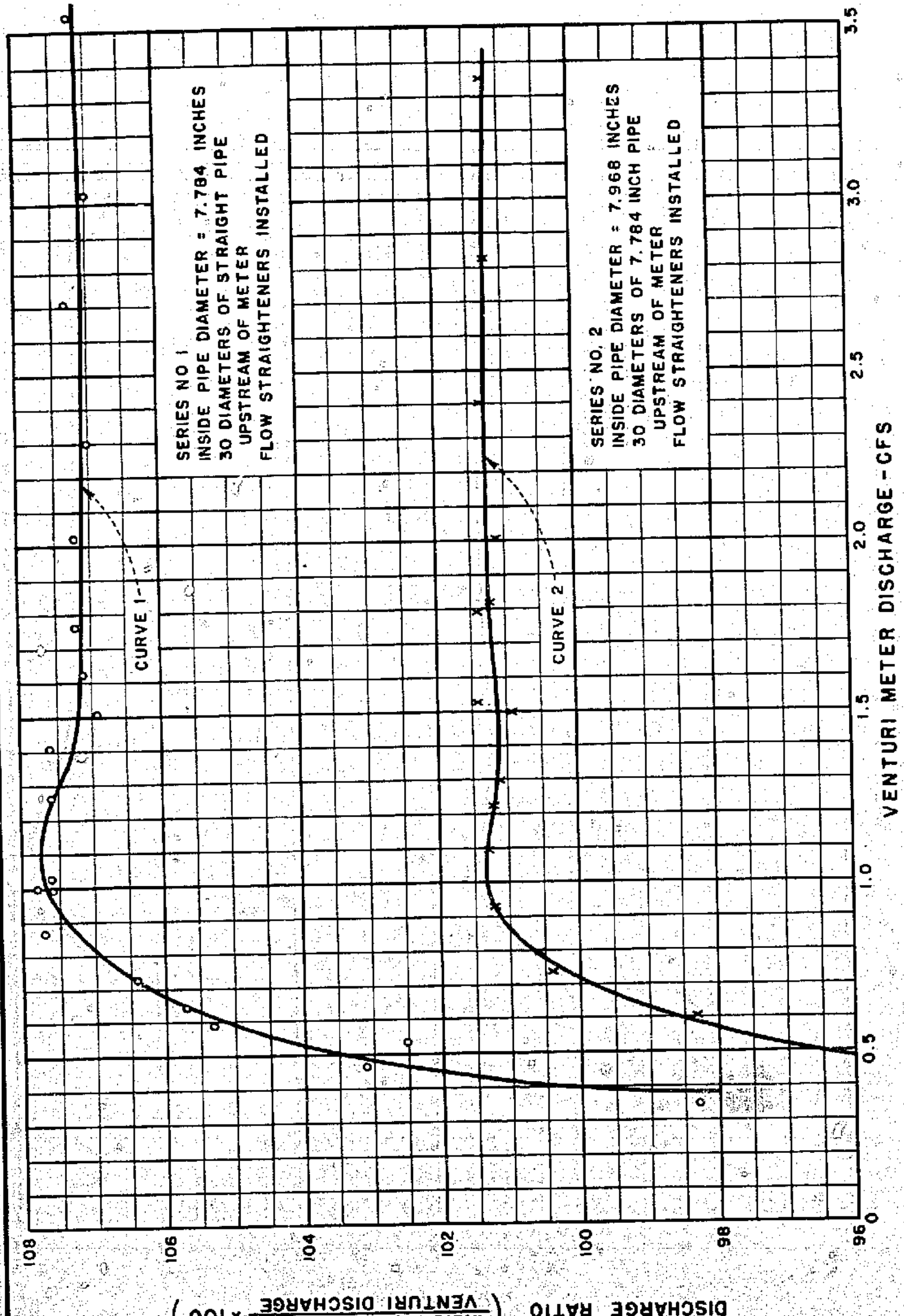
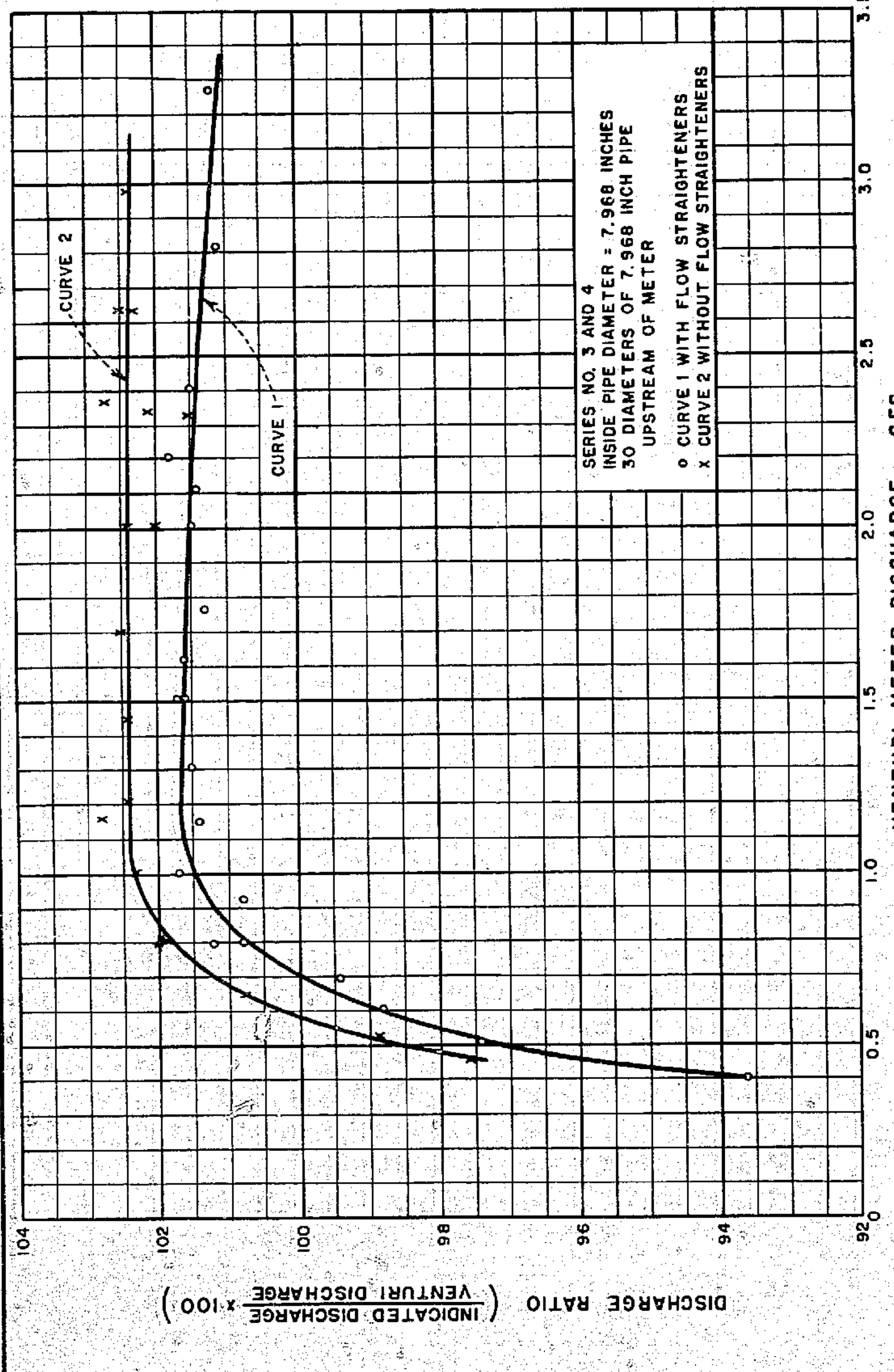



PROPELLER METER STUDY

METER CALIBRATION CURVES - EFFECT OF PIPE SIZE ON CALIBRATION

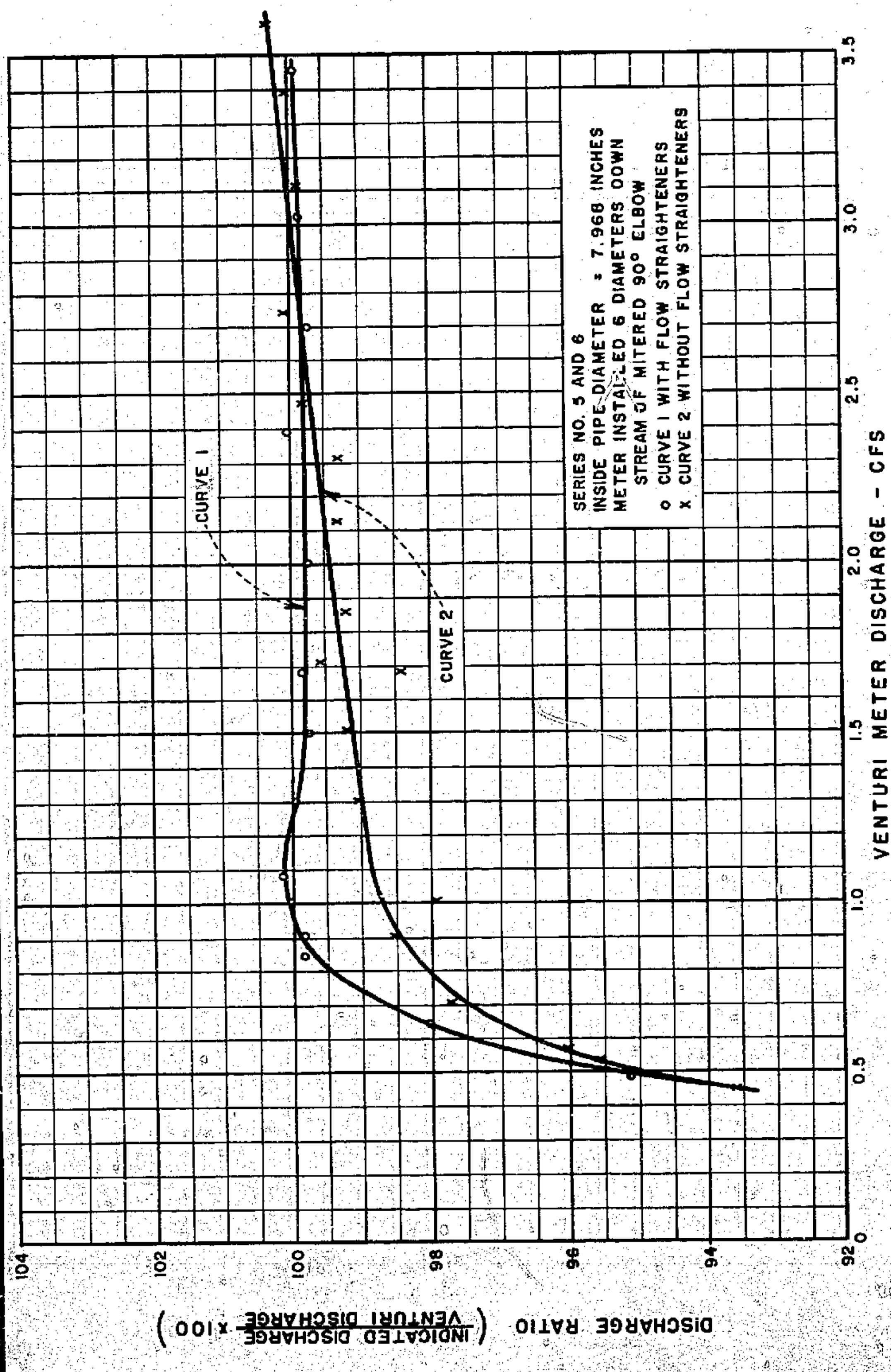
'08




PROPELLER METER STUDY

METER CALIBRATION CURVES - EFFECT OF FLOW STRAIGHTENERS ON REGISTRATION

FIGURE 6
REPORT HYD-558

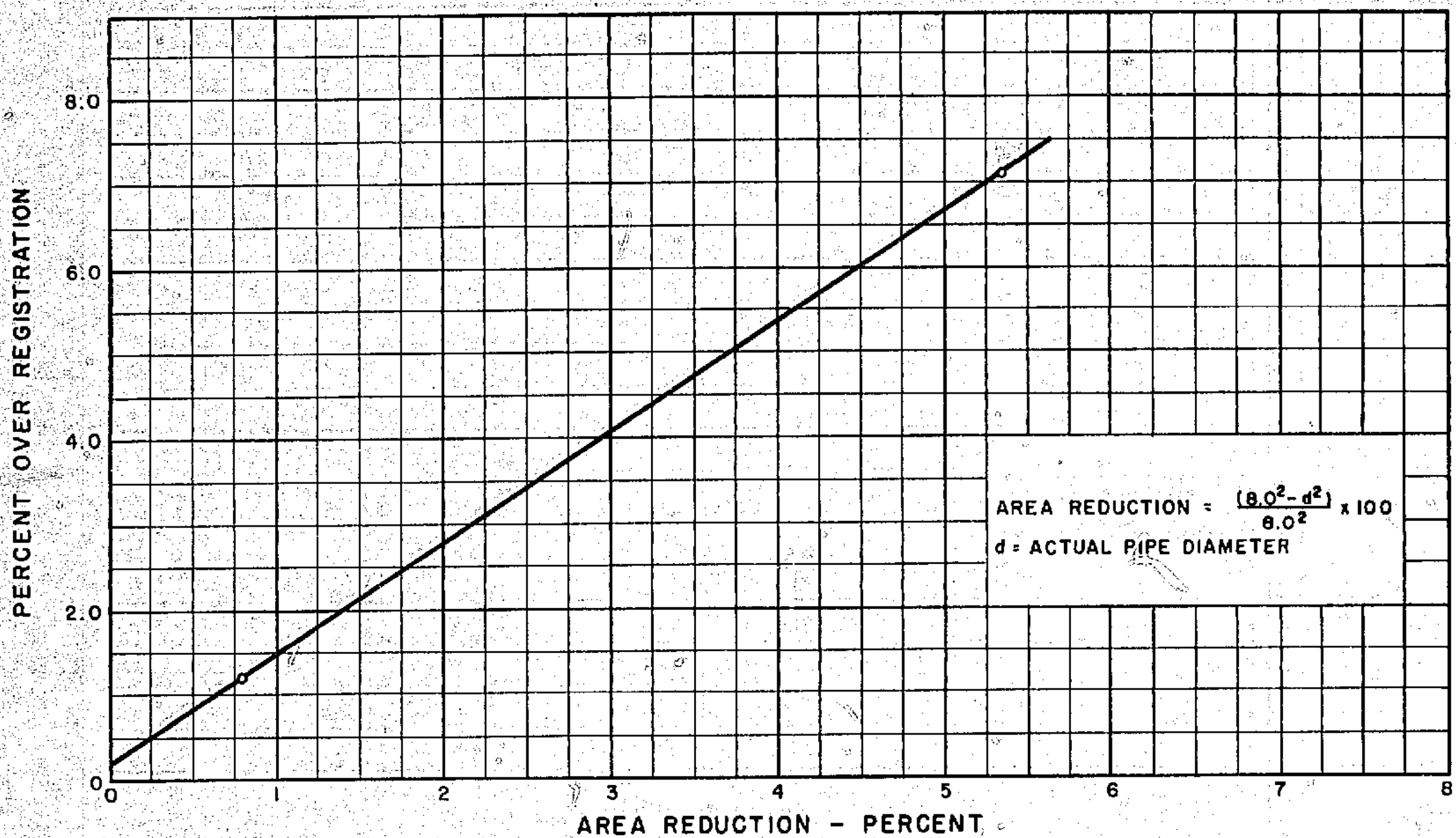



PROPELLER METER STUDY

METER CALIBRATION CURVES - METER INSTALLED DOWNSTREAM OF 90° ELBOW

708

GPO 859-881




PROPELLER METER STUDY
EFFECT OF PIPE AREA ON METER REGISTRATION

FIGURE 7
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# CONVERSION FACTORS--BRITISH TO METRIC UNITS OF MEASUREMENT

The following conversion factors adopted by the Bureau of Reclamation are those published by the American Society for Testing and Materials (ASTM Metric Practice Guide, January 1964) except that additional factors (*) commonly used in the Bureau have been added. Further discussion of definitions of quantities and units is given on pages 10-11 of the ASTM Metric Practice Guide.

The metric units and conversion factors adopted by the ASTM are based on the "International System of Units" (designated SI for Systeme International d'Unites), fixed by the International Committee for Weights and Measures; this system is also known as the Giorgi or MKSA (meter-kilogram (mass)-second-ampere) system. This system has been adopted by the International Organization for Standardization in ISO Recommendation R-31.

The metric technical unit of force is the kilogram-force; this is the force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 9.80665 m/sec/sec, the standard acceleration of free fall toward the earth's center for sea level at 45 deg latitude. The metric unit of force in SI units is the newton (N), which is defined as that force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 1 m/sec/sec. These units must be distinguished from the (inconstant) local weight of a body having a mass of 1 kg; that is, the weight of a body is that force with which a body is attracted to the earth and is equal to the mass of a body multiplied by the acceleration due to gravity. However, because it is general practice to use "pound" rather than the technically correct term "pound-force," the term "kilogram" (or derived mass unit) has been used in this guide instead of "kilogram-force" in expressing the conversion factors for forces. The newton unit of force will find increasing use, and is essential in SI units.

## Table 1

### QUANTITIES AND UNITS OF SPACE

| Multiply | By | To obtain |
|---|---|---|
| | **LENGTH** | |
| Mil | 25.4 (exactly) | Micron |
| Inches | 25.4 (exactly) | Millimeters |
| | 2.54 (exactly)* | Centimeters |
| Feet | 30.48 (exactly) | Centimeters |
| | 0.3048 (exactly)* | Meters |
| | 0.0003048 (exactly)* | Kilometers |
| Yards | 0.9144 (exactly) | Meters |
| Miles (statute) | 1,609.344 (exactly)* | Meters |
| | 1.609344 (exactly) | Kilometers |
| | **AREA** | |
| Square inches | 6.4516 (exactly) | Square centimeters |
| Square feet | 929.03 (exactly)* | Square centimeters |
| | 0.092903 (exactly) | Square meters |
| Square yards | 0.836127 | Square meters |
| Acres | 0.40469* | Hectares |
| | 4,046.9* | Square meters |
| | 0.0040469* | Square kilometers |
| Square miles | 2.58999 | Square kilometers |
| | **VOLUME** | |
| Cubic inches | 16.3871 | Cubic centimeters |
| Cubic feet | 0.0283168 | Cubic meters |
| Cubic yards | 0.764555 | Cubic meters |
| | **CAPACITY** | |
| Fluid ounces (U.S.) | 29.5737 | Cubic centimeters |
| | 29.5729 | Milliliters |
| Liquid pints (U.S.) | 0.473179 | Cubic decimeters |
| | 0.473166 | Liters |
| Quarts (U.S.) | 9,463.58 | Cubic centimeters |
| | 0.946358 | Liters |
| Gallons (U.S.) | 3,785.43* | Cubic centimeters |
| | 3.78543 | Cubic decimeters |
| | 3.78533 | Liters |
| | 0.00378543* | Cubic meters |
| Gallons (U.K.) | 4.54609 | Cubic decimeters |
| | 4.54596 | Liters |
| Cubic feet | 28.3160 | Liters |
| Cubic yards | 764.55* | Liters |
| Acre-feet | 1,233.5* | Cubic meters |
| | 1,233,500* | Liters |

## Table II

QUANTITIES AND UNITS OF MECHANICS

| Multiply | By | To obtain |
|---|---|---|
| | **MASS** | |
| Grains (1/7,000 lb) | 64.79891 (exactly) | Milligrams |
| Troy ounces (480 grains) | 31.1035 | Grams |
| Ounces (avdp) | 28.3495 | Grams |
| Pounds (avdp) | 0.45359237 (exactly) | Kilograms |
| Short tons (2,000 lb) | 907.185 | Kilograms |
| | 0.907185 | Metric tons |
| Long tons (2,240 lb) | 1,016.05 | Kilograms |
| | **FORCE/AREA** | |
| Pounds per square inch | 0.070307 | Kilograms per square centimeter |
| | 0.689476 | Newtons per square centimeter |
| Pounds per square foot | 4.88243 | Kilograms per square meter |
| | 47.8803 | Newtons per square meter |
| | **MASS/VOLUME (DENSITY)** | |
| Ounces per cubic inch | 1.72999 | Grams per cubic centimeter |
| Pounds per cubic foot | 16.0185 | Kilograms per cubic meter |
| | 0.0160185 | Grams per cubic centimeter |
| Tons (long) per cubic yard | 1.32894 | Grams per cubic centimeter |
| | **MASS/CAPACITY** | |
| Ounces per gallon (U.S.) | 7.4893 | Grams per liter |
| Ounces per gallon (U.K.) | 6.2362 | Grams per liter |
| Pounds per gallon (U.S.) | 119.829 | Grams per liter |
| Pounds per gallon (U.K.) | 99.779 | Grams per liter |
| | **BENDING MOMENT OR TORQUE** | |
| Inch-pounds | 0.011521 | Meter-kilograms |
| | $1.12985 \times 10^{6}$ | Centimeter-dynes |
| Foot-pounds | 0.138255 | Meter-kilograms |
| | $1.35582 \times 10^{7}$ | Centimeter-dynes |
| Foot-pounds per inch | 5.4431 | Centimeter-kilograms per centimeter |
| Ounce-inches | 72.008 | Gram-centimeters |
| | **VELOCITY** | |
| Feet per second | 30.48 (exactly) | Centimeters per second |
| | 0.3048 (exactly)* | Meters per second |
| Feet per year | $0.965873 \times 10^{-6}$* | Centimeters per second |
| Miles per hour | 1.609344 (exactly) | Kilometers per hour |
| | 0.44704 (exactly) | Meters per second |
| | **ACCELERATION*** | |
| Feet per second$^2$ | 0.3048* | Meters per second$^2$ |
| | **FLOW** | |
| Cubic feet per second (second-feet) | 0.028317* | Cubic meters per second |
| Cubic feet per minute | 0.4719 | Liters per second |
| Gallons (U.S.) per minute | 0.06309 | Liters per second |
| | **FORCE*** | |
| Pounds | 0.453592* | Kilograms |
| | 4.4482* | Newtons |
| | $4.4482 \times 10^{-5}$* | Dynes |
| | **WORK AND ENERGY*** | |
| British thermal units (Btu) | 0.252* | Kilogram calories |
| | 1,055.06 | Joules |
| Btu per pound | 2.326 (exactly) | Joules per gram |
| Foot-pounds | 1.35582* | Joules |
| | **POWER** | |
| Horsepower | 745.700 | Watts |
| Btu per hour | 0.293071 | Watts |
| Foot-pounds per second | 1.35582 | Watts |
| | **HEAT TRANSFER** | |
| Btu in./hr ft$^2$ deg F (k, thermal conductivity) | 1.442 | Milliwatts/cm deg C |
| | 0.1240 | Kg cal/hr m deg C |
| Btu ft/hr ft$^2$ deg F | 1.4880* | Kg cal m/hr m$^2$ deg C |
| Btu/hr ft$^2$ deg F (C, thermal conductance) | 0.568 | Milliwatts/cm$^2$ deg C |
| | 4.882 | Kg cal/hr m$^2$ deg C |
| Deg F hr ft$^2$/Btu (R, thermal resistance) | 1.761 | Deg C cm$^2$/milliwatt |
| Btu/lb deg F (c, heat capacity) | 4.1868 | J/g deg C |
| Btu/lb deg F | 1.000* | Cal/gram deg C |
| Ft$^2$/hr (thermal diffusivity) | 0.2581 | Cm$^2$/sec |
| | 0.09290* | M$^2$/hr |
| | **WATER VAPOR TRANSMISSION** | |
| Grains/hr ft$^2$ (water vapor transmission) | 16.7 | Grams/24 hr m$^2$ |
| Perms (permeance) | 0.659 | Metric perms |
| Perm-inches (permeability) | 1.67 | Metric perm-centimeters |

## Table III

OTHER QUANTITIES AND UNITS

| Multiply | By | To obtain |
|---|---|---|
| Cubic feet per square foot per day (seepage) | 304.8* | Liters per square meter per day |
| Pound-seconds per square foot (viscosity) | 4.8824* | Kilogram second per square meter |
| Square feet per second (viscosity) | 0.02903* (exactly) | Square meters per second |
| Fahrenheit degrees (change)* | 5/9 exactly | Celsius or Kelvin degrees (change)* |
| Volts per mil | 0.03937 | Kilovolts per millimeter |
| Lumens per square foot (foot-candles) | 10.764 | Lumens per square meter |
| Ohm-circular mils per foot | 0.001662 | Ohm-square millimeters per meter |
| Millicuries per cubic foot | 35.3147* | Millicuries per cubic meter |
| Milliamps per square foot | 10.7639* | Milliamps per square meter |
| Gallons per square yard | 4.527219* | Liters per square meter |
| Pounds per inch | 0.17858* | Kilograms per centimeter |

## ABSTRACT

An 8-in. saddle-type propeller meter was calibrated in the laboratory for normal installation with 30 diameters of straight pipe upstream of the meter and for a severe test of accuracy with the meter installed 6 diameters downstream of a 90 deg mitered elbow. Discharges indicated by the propeller meter, obtained by timing the totalizer register in the meter head, were compared to values obtained simultaneously using the Venturi meters installed in the hydraulics laboratory for use as measuring devices. The Venturi meters, volumetrically calibrated, are accurate to within ±0.5% of the actual flow. The meter was tested in 2 different sizes of pipe, and the effect of flow straighteners on the meter accuracy was investigated. For the normal installation with flow straighteners, the meter accuracy was ±2% for discharges between 0.55 to 3.33 cfs; but the accuracy decreased in the lower range of 0.22 to 0.55 cfs. For the meter downstream of the elbow, the accuracy was ±2% for discharges from 0.65 to 3.33 cfs. In both installations, the meter read as much as 13% low at the minimum-rated discharge of 0.22 cfs. Flow straighteners increased the meter accuracy by as much as 1.5% in both installations. Tests of the meter in 2 sizes of pipe showed best accuracy when the inside diameter of the pipe was 8.00 in.

## ABSTRACT

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USBR Lab Rept Hyd-558, Hyd Br, August 29, 1966. Bureau of Reclamation, Denver, 6 p, 7 fig

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